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Anonymity in a Mobile Computing Environment

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Abstract

In a mobile computing environment, it is desirable to protect information about the movements and activities of mobile entities from onlookers. Solutions to this problem of providing anonymity have to be developed with the constraints of mobile computing environments in mind. In this paper, it is argued that this issue merits investigation. A brief survey of the nature of anonymity provided in proposed or existing mobile computing environments is presented. It is argued further that achieving limited but practical anonymity using standard cryptographic techniques is feasible. Example solutions are presented.

1 Introduction to the Problem

In a distributed system where some entities (i.e. users and computing devices) are mobile, it is often desirable to keep information about their movements, locations and activities confidential. The modalities of providing such *anonymity* depend on the underlying security infrastructure of the system. Typically, this infrastructure is built using a shared key cryptosystem (SKCS), a public key cryptosystem (PKCS) or a hybrid system.

Anonymity has two aspects [4]. *Anonymity of location* deals with keeping an entity's movements and whereabouts confidential. *Anonymity of data origin/destination* deals with keeping an entity's activities confidential. The latter seeks to prevent an onlooker from associating the entity with messages sent to/from it or with the sessions in which it is a participant. Within the context of this paper, anonymity as a goal does not imply unrestrained anonymity; it implies the protection of relevant information from *unintended* parties. For example, I assume that a server may demand that a potential client reveal its true identity and perhaps provide adequate authentication as a prerequisite to the use of services.

In traditional computing environments, with fixed entities and wireline networks, anonymity of location

has not been considered a significant issue. In a mobile computing environment, it assumes greater importance. It is likely to be an important security problem to solve before mobile computing gains wide acceptance. Anonymity is especially desirable when an entity travels outside of its 'home domain.'¹ In spite of that, it has not been considered a basic requirement in designing protocols for mobile computing environments (e.g. the IETF mobile-IP effort [12] has not yet addressed this issue). Like every other aspect of security, provision of anonymity is tightly coupled with the architecture of the rest of the system. For instance, providing anonymity of network layer identity will be of little use if the routing protocol uses re-direction: an onlooker who has access to a router elsewhere on the system can determine the whereabouts of a mobile entity by trying to send a message to it. Therefore, the problem of providing anonymity should be considered during the design stage of building mobile computing environments.

There are philosophical motivations for providing anonymity as well. An entity that chooses to protect its location and activities from unintended third parties must have the mechanisms available to do so even if openness and full disclosure is a common policy. Besides, the principle of least information is a good rule to live by in designing security systems.

The rest of this document describes some proposed solutions to the anonymity problem and makes suggestions for improving them. The basic theme behind the suggestions is that effective anonymity can be achieved by making a *limited disclosure* of information.

¹A domain consists of entities that fall within a common administrative control.

2 Solutions

Notation

X_K - A message X encrypted/sealed by a key K .
 K_{AB} - A secret key shared between parties A , B .
 K_A , K_A^{-1} - Public and private key pair of A .
 N_A - A nonce created by A .
 M - Mobile entity.
 R - Remote domain M is visiting.
 H - M 's home domain.
 D - M 's current domain. (H or some R)

2.1 Shared Key Cryptosystems

In a distributed system with a security infrastructure based on a SKCS, an entity (the 'client') authenticates itself to another entity (the 'server') by demonstrating the possession of a secret key shared between them. To do this, the client has to first announce its (claimed) identity in the clear. This makes it hard to provide anonymity of location.

An intuitive solution is to use the notion of *nicknames*. Molva et. al. [11] suggest that a mobile entity could use a *traveling alias* when it travels in foreign domains. Only the mobile entity and its home domain will know the mapping between the traveling alias M_t and the real identity M . They go on to suggest that M_t be changed "at regular intervals; perhaps as often as passwords or PINs." However, in the absence of a protocol to change traveling aliases over an insecure channel, entities can change traveling aliases only when they return to their home domain. Such traveling aliases with fairly long lifetimes may be problematic in certain circumstances. For example, as mentioned before, the mobile entity may be called upon to reveal (and even prove) its real identity M before being granted certain services in foreign domains. With time, the set of entities that know the mapping between M_t and M will grow. Further, an onlooker will be able to use a long lived alias M_t to link the various activities of M for the period during which the alias remains in effect.

An alternative is to use short-lived aliases [8]. Aliases are changed by mutual agreement between the mobile entity and its home domain server. This implies that the mobile and the home domain stay synchronized. If synchronization is lost, a sub-protocol is necessary for re-synchronization. Achieving re-synchronization securely is a challenge. In [8] the mobile entity may be required to send its identity in the clear in order to achieve resynchronization. This, as observed in the same document, constitutes a "breach in the provision of the service."

Loss of synchronization is likely to be rare. In addition, the home domain is likely to have significant computing resources at its disposal. Therefore, in the event of loss of synchronization, I suggest that it may be reasonable to expect the mobile M to simply send a message to H encrypted with K_{HM} . H can then search through its database of shared secret keys until it finds one that can extract the message. If the number of entities in H 's jurisdiction renders this an expensive operation, then I suggest that H can divide the principals into groups of manageable sizes, each with a unique group identifier. When synchronization is lost, M can send an encrypted message along with its group identifier. This way, a reduced level of anonymity can be provided by making a *limited disclosure* of information.

Preserving anonymity of data origin is similar to preserving anonymity of location. Anonymity of data destination is somewhat different when the destination is a mobile entity. Carlsen's solution [4] suggests essentially (see below for a clarification) the following: a domain server D that wants to send a message to a mobile M currently present in its domain, will multicast a message $\{M, K_s\}_{K_{DM}}$ to all the mobile entities currently present in the domain. Each mobile will attempt to decrypt every such multicast message. Only M will be able to recover the message and the session key K_s , which can be used to secure the subsequent session. Carlsen argues that in a portable (voice) communication system, such a computing load on mobile entities is reasonable assuming 3 calls per hour. The arguments may not be applicable in a data communication system where the frequency of messages to a mobile entity can be potentially much higher. Carlsen's model actually consists of various *ports* (or base stations in more common parlance). Each port serves a number of mobile entities that happen to be inside its region. Thus, it is a port which attempts to send a message to a mobile M without revealing M 's identity to an onlooker. The description here is conceptually similar to Carlsen's solution.

2.2 Public Key Cryptosystems

Public key cryptosystems can provide location and data origin anonymity in a natural way. The mobile M can use the domain server D 's public key K_D to encrypt messages to it. Within an administrative domain, each M can be required to know the public key K_H of its home domain server. However, when M wanders into a different domain R , it cannot be expected to know the public key, K_R . It has to identify itself first so that R can determine how to *mutually* authenticate M . The decrypt-on-the-fly solution

by Carlsen [4] to provide anonymity of data destination (as described in the previous section) will be prohibitively expensive in the case of a PKCS.

Some researchers [7][9] have discouraged the use of a PKCS to build authentication protocols for environments with mobile entities. The rationale for this recommendation is that the computational complexity of known PKCSs are beyond the limited resources available to mobile entities. Even if this argument is valid for a specific environment, it is likely to be a temporary limitation. What is more relevant is the *asymmetry* in available resources between mobile entities and their stationary counterparts. Beller et. al. observe [2] that it is feasible to design practical authentication mechanisms using PKCSs keeping this asymmetry in mind.

2.3 A Hybrid Solution

Complete anonymity may be hard to achieve. But it might also not be an absolute requirement. The earlier notion of *limited disclosure* can again be used to achieve practical anonymity. For instance, it might be acceptable to reveal that the visiting mobile entity is from domain H (or a suitably large super-domain of H), without revealing its exact identity. A hybrid protocol can provide such limited anonymity without being too complicated. In the rest of this section I describe an example protocol for authenticating a mobile entity using the above notion of limited disclosure.

Consider the following model: the system is partitioned into domains. The authentication server in domain H shares a secret key with every entity in the domain. H 's public key is known to every entity in its domain. Each pair of domains H and R have (or using an inter-domain key distribution protocol, can dynamically arrange to have) a shared key K_{HR} .² The remote server R will provide services to the visiting mobile M only if (a) M 's true identity is revealed to it and (b) the authenticity of the claimed identity is adequately demonstrated. Finally, all network links are considered to be insecure channels in which an intruder can observe, modify or destroy data. The goal is to achieve satisfactory mutual authentication between M and R while minimizing the set of entities that can infer the presence of M in R by watching the traffic.

The authentication protocol works as follows:

When a mobile M shows up in a remote domain R , it begins the registration process by identifying

²Designing a scalable key distribution mechanism is another security problem that has been made more urgent by the advent of mobile computing. While there have been proposals to solve this problem by imposing a hierarchy of trust, such a hierarchy is not acceptable in all situations. This remains an open issue.

its home domain H and presenting its credentials encrypted with the public key of H . I assume that M can compute the key K_{MR} which is to be used for the mutual authentication. I elaborate on the computation of K_{MR} below. The first message is sent from the M to R as follows:

M1: $M \Rightarrow R : Cred_{MR}, H, \{M, R, N_M\}_{K_{MR}}$

Where,

$$Cred_{MR} = \{M, R, H, \{T_M\}_{K_{MH}}\}_{K_H}$$

T_M is either a time stamp (which will imply the need for loosely synchronized clocks) or some indicator of freshness (e.g. a nonce that was handed to M the last time it authenticated successfully to H). In this description, I will assume that T_M is the current timestamp. R cannot verify the credentials. It can however find and mutually authenticate H and pass the credentials to it. The second message is from R to H as follows:

M2: $R \Rightarrow H : \{R, Cred_{MR}, N_R\}_{K_{HR}}, R$

H can verify the veracity and timeliness of the message from M . If the verification succeeds, H has to send the necessary information back to complete mutual authentication between M and R . The exact nature of this information depends on the assumptions made. For example, if T_M is a nonce and not a timestamp, H has to generate a new nonce to be sent back to M so that it can be used in the next protocol run. H also needs to inform R (and perhaps M) of the key K_{MR} that is to be used to secure the channel between M and R . H can pick a random key K_{MR} to be used by M and R . Or K_{MR} can be derived from other information that is unique to a given protocol run. For example, K_{MR} can be a one-way hash function $h(K_{MH}, R, T_M)$. In this case, M already possesses enough information to compute K_{MR} when it initiates the protocol. I use the latter. This is why I stated that M can compute K_{MR} and use it to encrypt the second part of the message $M1$. The third message is from H to R as follows:

M3: $H \Rightarrow R : Tick_{HR}$

Where,

$$Tick_{HR} = \{R, H, M, K_{MR}, N_R\}_{K_{HR}}$$

R can now know the true identity of M . It can also extract the key K_{MR} using which it can extract

the second part of message $M1$. It can use these to complete the mutual authentication with M as follows:

$M4: R \Rightarrow M : \{N'_R, N_M, M, R\}_{K_{MR}}$

M can use the already computed K_{MR} to extract this message. It can verify that this response is timely by checking for the presence of its nonce N_M inside. It can then respond to the challenge by demonstrating to R that it was able to extract the nonce N'_R .

$M5: M \Rightarrow R : \{M, R, N'_R\}_{K_{MR}}$

Several variations to this example protocol are possible. For example, in message $M5$, R can allocate a temporary identifier to M as in [11] to be used in subsequent messages from and to M while it is in R . The same K_{MR} is expected to be used for mutual authentication between M and R for subsequent connection attempts for the entire duration of M 's stay in R . But R or M can force a re-authentication involving H at any time, should they feel the need to do so.

This protocol provides limited anonymity since an onlooker can only know that an entity from H visited R but cannot determine the exact identity of the entity. It is scalable in that it can provide anonymity to an arbitrary level of granularity: instead of specifying H , M could have identified some parent domain H' of H and used $K_{H'}$ to encode its identity relative to H' . While H' shares no secret with M and therefore cannot verify the authenticity directly, it can form a trusted path to H and pass along the credentials. This protocol also takes the asymmetry of computing power into account: the mobile entities transfer the burden of verifying authenticity to their home domains. Even if the inter-domain key distribution protocol was based on a PKCS, the expensive task of verifying a chain of certificates provided by R will fall on H and not on M . There is only one public key operation (encryption using H 's public key) that M has to perform. In general, the public key operations of a PKCS are less expensive than the private key operations. M has to store a small, finite number of keys in its permanent storage (e.g. K_{MH} and K_H). It also needs to store K_{MR} (or enough information to re-compute K_{MR}) for the duration of its stay in R .

A correctness proof of this protocol using the BAN logic [3] appears in [1]. However, the proof only establishes that the authentication protocol is correct. In future work, I hope to investigate how the analysis techniques can be used to draw formal conclusions

about the preservation of anonymity.

3 Related Work

A referee pointed me to the work done by David Chaum. Chaum and others have done extensive work on unconditionally anonymous protocols to implement, among other things, the digital equivalent of cash. The basic theme of security (for providing and/or using services and products) without identification is expounded by Chaum in [6]. By requiring that the security of a transaction not be dependent on establishing the identities of participants to one another, it is possible to design protocols that achieve complete unconditional anonymity. Unconditional anonymity also opens the possibility of "perfect crime" (See [13], page 123, for a reference). Chaum uses the phrase "limited anonymity" in [5] to denote the anonymity provided by a special set of protocols. These protocols, like the unconditional anonymity protocols, preserve the anonymity of participants from onlookers and from each other. However, if necessary (for example, by a court warrant), the anonymity of a transaction can be undone at a later time.

In this paper, I assume that the legitimate parties involved in a transaction can demand to know the real identities of the other parties. The concern here is to protect the identities of certain parties involved in the transaction from other onlookers who are not legitimate parties to the transaction. By "limited anonymity" I mean that some information about the identity of a participant is leaked to an eavesdropping third party.

The ideas presented here are intuitive. Similar ideas have been used in different contexts. In [10], Maxemchuk et. al. describe various protocols for providing anonymity using a building block called "Double Locked Box Protocol." Using this protocol, an entity A can send a message to another entity B via an intermediary I . A starts by sealing the identity of B in a box that only B 's computer can open. This box is placed inside another box, along with the identity of B 's computer and sealed so that only the intermediary I can open the outer box. The box is then handed to A 's computer. A 's computer cannot see what is inside but knows that it needs to be passed to I . I can get no information about the sender or recipient except the identities of their computers. B 's computer, which receives the inner box from I knows nothing about the sender. As is evident, the basic idea is that by disclosing a limited amount of information in the clear, significant anonymity can be obtained.

4 Conclusion

Anonymity has not been a major issue in traditional distributed systems like the Internet. But the advent of mobile computing has provided strong motivations to address this problem. Providing complete anonymity is often hard, infeasible or undesirable. This document has made suggestions that can help provide limited but practical anonymity by using *limited disclosure* of information. Provision of anonymity, and security issues in general, must be taken into account while mobile computing environments are being designed.

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Anonymity in a mobile computing environment

[Asokan, N.](#)

Dept. of Comput. Sci., Waterloo Univ., Ont., Canada;

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Abstract

In a **mobile computing** environment, it is desirable to protect information about the move of mobile entities from onlookers. Solutions to this problem of providing anonymity have t the constraints of **mobile computing** environments in mind. It is argued that this issue m brief survey of the nature of anonymity provided in proposed or existing **mobile computi** presented. It is argued further that achieving limited but practical anonymity using standa techniques is feasible. Example solutions are presented

Index Terms

Inspec

Controlled Indexing

[cryptography](#) [data privacy](#) [mobile communication](#) [telecommunication comput](#)

Non-controlled Indexing

[anonymity](#) [mobile computing environment](#) [mobile entities](#) [standard cryptogr techniques](#)

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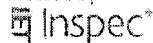
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IEEE CNF IEEE Conference Proceeding

IET CNF IET Conference Proceeding

IEEE STD IEEE Standard

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IEEE JNL IEEE Journal or Magazine

IET JNL IET Journal or Magazine

IEEE CNF IEEE Conference Proceeding

IET CNF IET Conference Proceeding

IEEE STD IEEE Standard

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1 [Object orientation in multidatabase systems](#)



Evaggelia Pitoura, Omran Bukhres, Ahmed Elmagarmid

 June 1995 **ACM Computing Surveys (CSUR)**, Volume 27 Issue 2

Publisher: ACM Press

Full text available: pdf(4.85 MB)

 Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#), [review](#)

A multidatabase system (MDBS) is a confederation of preexisting distributed, heterogeneous, and autonomous database systems. There has been a recent proliferation of research suggesting the application of object-oriented techniques to facilitate the complex task of designing and implementing MDBSs. Although this approach seems promising, the lack of a general framework impedes any further development. The goal of this paper is to provide a concrete analysis and categorization of the various ...

Keywords: distributed objects, federated databases, integration, multidatabases, views

2 [Special topic section on peer to peer data management: DBGlobe: a service-oriented P2P system for global computing](#)



Evaggelia Pitoura, Serge Abiteboul, Dieter Pfoser, George Samaras, Michalis Vazirgiannis

 September 2003 **ACM SIGMOD Record**, Volume 32 Issue 3

Publisher: ACM Press

Full text available: pdf(282.99 KB)

 Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#)

The challenge of peer-to-peer computing goes beyond simple file sharing. In the DBGlobe project, we view the multitude of peers carrying data and services as a superdatabase. Our goal is to develop a data management system for modeling, indexing and querying data hosted by such massively distributed, autonomous and possibly mobile peers. We employ a service-oriented approach, in that data are encapsulated in services. Direct querying of data is also supported by an XML-based query language. In t ...

Keywords: global computing, metadata, peer-to-peer computing, peer-to-peer databases, pervasive computing, services, ubiquitous computing

3 [Exploiting Versions for Handling Updates in Broadcast Disks](#)

Evaggelia Pitoura, Panos K. Chrysanthis

 September 1999 **Proceedings of the 25th International Conference on Very Large Data**

Bases VLDB '99**Publisher:** Morgan Kaufmann Publishers Inc.Additional Information: [full citation](#), [citations](#)**4** Location-based services and mobile computing: data models: Metadata modeling in a global computing environment

Dieter Pfoser, Evaggelia Pitoura, Nectaria Tryfona

November 2002 **Proceedings of the 10th ACM international symposium on Advances in geographic information systems GIS '02****Publisher:** ACM PressFull text available: [pdf\(264.88 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

Emerging computational paradigms such as global and ubiquitous computing require some rethinking and innovative research ideas in many computer science areas. In this work, we aim at studying a mobile computing scenario from the database perspective. Given a global computing environment in which data is kept in a number of small-scale, data-charged, mobile devices that use, e.g., wireless networks, for communication, we want to assess the overall data scenario. We use an example to abstract the ...

Keywords: global computing, metadata, mobile computing, mobile devices, mobile ontologies, spatiotemporal databases

5 Keep your data safe and available while roaming

Yolanda Villate, Arantza Illarramendi, Evaggelia Pitoura

August 2002 **Mobile Networks and Applications**, Volume 7 Issue 4**Publisher:** Kluwer Academic PublishersFull text available: [pdf\(314.83 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [index terms](#)

The possibility of accessing and/or receiving local or remote data anywhere and at anytime constitutes an important advantage in many business environments. However, when working with mobile devices, users face many problems, such as: (1) *device exposure problems* --- mobile devices are more vulnerable and fragile than stationary devices, because they can be easily stolen, lost or damaged, (2) *media problems* --- wireless communications are often unstable, asymmetric and expensive, a ...

Keywords: data storage, mobile computing, multi-agents systems, wireless services

6 Proceedings of the 2nd ACM international workshop on Data engineering for wireless and mobile access

Krithi Ramamritham, Panos K. Chrysanthis, Evaggelia Pitoura

May 2001 proceeding


Publisher: ACM PressAdditional Information: [full citation](#), [index terms](#)**7** An efficient hierarchical scheme for locating highly mobile users

Evaggelia Pitoura, Ioannis Fudos

November 1998 **Proceedings of the seventh international conference on Information and knowledge management CIKM '98****Publisher:** ACM Press

Full text available:  [pdf\(1.30 MB\)](#) Additional Information: [full citation](#), [references](#), [citings](#), [index terms](#)

8 A view-based approach to relaxing global serializability in a multidatabase system

 Evaggelia Pitoura, Aidong Zhang, Bharat Bhargava
August 1995 **Proceedings of the fourteenth annual ACM symposium on Principles of distributed computing PODC '95**

Publisher: ACM Press

Full text available:  [pdf\(130.10 KB\)](#) Additional Information: [full citation](#), [index terms](#)

9 Digital library services in mobile computing

 Bharat Bhargava, Melliya Annamalai, Evaggelia Pitoura
December 1995 **ACM SIGMOD Record**, Volume 24 Issue 4

Publisher: ACM Press

Full text available:  [pdf\(554.86 KB\)](#) Additional Information: [full citation](#), [abstract](#), [citings](#), [index terms](#)

Digital libraries bring about the integration, management, and communication of gigabytes of multimedia data in a distributed environment. Digital library systems currently envision users as being static when they access information. But it is expected in the near future that tens of millions of users will have access to a digital library through wireless access. Providing digital library services to users whose location is constantly changing, whose network connections are through a wirele ...

10 A framework for providing consistent and recoverable agent-based access to heterogeneous mobile databases

 Evaggelia Pitoura, Bharat Bhargava
September 1995 **ACM SIGMOD Record**, Volume 24 Issue 3

Publisher: ACM Press

Full text available:  [pdf\(728.00 KB\)](#) Additional Information: [full citation](#), [abstract](#), [citings](#), [index terms](#)


Information applications are increasingly required to be distributed among numerous remote sites through both wireless and wired links. Traditional models of distributed computing are inadequate to overcome the communication barrier this generates and to support the development of complex applications. In this paper, we advocate an approach based on agents. Agents are software modules that encapsulate data and code, cooperate to solve complicated tasks, and run at remote sites with minimum inter ...

Keywords: agents, concurrency control, mobile computing, multidatabases, recovery, transactions, workflow

11 Building information systems for mobile environments

 Evaggelia Pitoura, Bharat Bhargava
November 1994 **Proceedings of the third international conference on Information and knowledge management CIKM '94**

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Full text available:  [pdf\(907.91 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citings](#), [index terms](#)

It is expected that in the near future, tens of millions of users will have access to distributed information systems through wireless connections. The technical characteristics of the wireless medium and the resulting mobility of both data resources and data consumers raise new challenging questions regarding the development of information systems appropriate for mobile environments. In this paper, we report on the

development of such a system. First, we describe the general architecture o ...

Keywords: consistency, information systems, mobile computing, new applications, transaction management

12 Paper session DB-8 (databases): query optimisation: Query workload-aware overlay construction using histograms

Georgia Koloniari, Yannis Petrakis, Evaggelia Pitoura, Thodoris Tsotsos
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Peer-to-peer(p2p) systems over an efficient means of data sharing among a dynamically changing set of a large number of a tonomous nodes.Each node in a p2p system is connected with a small number of other nodes thus creating an overlay network of nodes. A query posed at a node is routed through the overlay network towards nodes hosting data items that satisfy it. In this paper, we consider building overlays that exploit the query workload so that nodes are clustered based on their results to a g ...

Keywords: clustering, overlay network, peer-to-peer systems, query routing, range queries, small worlds

13 Research articles and surveys: Peer-to-peer management of XML data: issues and research challenges

Georgia Koloniari, Evaggelia Pitoura
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Peer-to-peer (p2p) systems are attracting increasing attention as an efficient means of sharing data among large, diverse and dynamic sets of users. The widespread use of XML as a standard for representing and exchanging data in the Internet suggests using XML for describing data shared in a p2p system. However, sharing XML data imposes new challenges in p2p systems related to supporting advanced querying beyond simple keyword-based retrieval. In this paper, we focus on data management issues fo ...

14 Paper session I: quality models: ETL queues for active data warehousing

Alexandros Karakasidis, Panos Vassiliadis, Evaggelia Pitoura
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Traditionally, the refreshment of data warehouses has been performed in an off-line fashion. Active Data Warehousing refers to a new trend where data warehouses are updated as frequently as possible, to accommodate the high demands of users for fresh data. In this paper, we propose a framework for the implementation of active data warehousing, with the following goals: (a) minimal changes in the software configuration of the source, (b) minimal overhead for the source due to the active nature of ...

15 Mobility in agents, sensors and services: Concept-based discovery of mobile services

Chara Skouteli, George Samaras, Evaggelia Pitoura
May 2005 **Proceedings of the 6th international conference on Mobile data**

management MDM '05**Publisher:** ACM PressFull text available:  [pdf\(292.22 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#)


In this paper, we consider semantic service discovery in a global computing environment. We propose creating a dynamic overlay network by grouping together semantically related services. Each such group of services is termed a community. Communities are organized in a global taxonomy whose nodes are related contextually. The taxonomy can be seen as an expandable distributed semantic index over the system services, which aims at improving service discovery. Our performance results indicate that i ...

Keywords: mobile computing, pervasive computing, service discovery**16** [Guest editorial](#)

Panos K. Chrysanthis, Evaggelia Pitoura

November 2004 **Wireless Networks**, Volume 10 Issue 6**Publisher:** Kluwer Academic PublishersFull text available:  [pdf\(38.82 KB\)](#) Additional Information: [full citation](#), [index terms](#)**17** [Special issue on Mobile Data Management: Mobile agent-based services for view materialization](#)


Kyriakos Karenos, George Samaras, Panos K. Chrysanthis, Evaggelia Pitoura

July 2004 **ACM SIGMOBILE Mobile Computing and Communications Review**, Volume 8 Issue 3**Publisher:** ACM PressFull text available:  [pdf\(537.45 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#)

Mobile agents are ideal for mobile computing environments because of their ability to support asynchronous communication and disconnected data processing. In this paper, we present a prototype set of extensible mobile-agent based services that allow the definition, materialization, maintenance and sharing of views created over remote web-accessible datasources, called V<i>i</i>SMA (Views Supported by Mobile Agents). V<i>i</i>SMA's primary goal is to support the customization a ...

18 [Communication Issues in Wide Area Networks for Digital Libraries \(abstract only\)](#)

Bharat Bhargava, Melliya Annamalai, Shalab Goel, Shunge Li, Evaggelia Pitoura

August 1994 **ACM SIGOIS Bulletin**, Volume 15 Issue 1**Publisher:** ACM PressFull text available:  [pdf\(132.06 KB\)](#) Additional Information: [full citation](#)

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Building Information Systems for Mobile Environments

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Abstract

It is expected that in the near future, tens of millions of users will have access to distributed information systems through wireless connections. The technical characteristics of the wireless medium and the resulting mobility of both data resources and data consumers raise new challenging questions regarding the development of information systems appropriate for mobile environments. In this paper, we report on the development of such a system. First, we describe the general architecture of the information system and the main considerations of our design. Then, based on these considerations, we present our system support for maintaining the consistency of replicated data and for providing transaction schemas that account for the frequent but predictable disconnections, the mobility, and the vulnerability of the wireless environment.

Keywords: New Applications, Information Systems, Mobile Computing, Transaction Management, Consistency.

1 Introduction

In the recent past, technical advances in the development of portable computers and the rapidly expanding cordless technology have provided the basis for accessing information systems through wireless connections. Today, when users move, unplug their computer from some local area network, transport it, and plug it back to the local area network at their destination. Wireless technology provides users with the ability to retain their network connection even while moving. This new computing paradigm is called *mobile* or *nomadic* computing. Mobile computing can be viewed as adding a new dimension to the broader vision of universal access to information that allows the mobility of data consumers and data resources.

Until recently, infrastructure research pertaining to mobile computing has mostly focused on networking and operating systems [18, 8, 17, 25, 4, 23]. Research in networking

and communications includes new addressing and routing schemas, support for efficient multicasting and broadcasting, data compression, and relocation transparency. Research in operating system addresses security issues, file systems that support disconnected operation, and caching techniques. However, the issues introduced go beyond those areas and directly affect information management systems [3, 15, 20]. Mobile computing introduces new challenging problems concerning resource management, information acquisition [16], and data distribution [13].

In this paper, we report on the design of an information system for a mobile environment. The goal of this paper is twofold. First, we give a general overview of the organization of the system and of the important concerns of our design. Second, we focus on our system support for consistency and transactions and show how our schema is in compliance with the general architecture and design concerns.

The structure of this paper is as follows. In Section 2, we introduce the physical architecture, and identify the characteristics of both the wireless medium and the mobile hosts. In Section 3, we define the operation modes of a mobile host, present the general object-based architecture of the information system, and introduce the main considerations of the design. The following two sections focus on consistency and transaction management. Section 4 describes our schema for maintaining the consistency of replicated data. The novelty of this schema is the existence of two types of operations (loose and strict) that allows users to specify the required degree of consistency of their input data. The schema takes into consideration the modes of operation and the peculiarities of the mobile environment. Section 5 discusses the structure of a mobile computation. We argue that flat transactions are inadequate for modeling interactions in a mobile environment and we propose appropriate extensions that account for mobility and recovery. In Section 6, we report briefly on the status of our system. We conclude in Section 7 by summarizing the main results of our work.

2 The Characteristics of the Mobile Environment

Distributed systems that support mobility are physically structured as shown in Figure 1 [15]. The architecture consists of two distinct types of hosts: mobile and fixed hosts. Some of the fixed hosts, called *base stations* or *mobile support stations*, are augmented with a wireless interface to communicate with mobile hosts. The geographical area covered by a base station is called a *cell*. Each mobile host can directly communicate with one base station, the one cover-

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ing the geographical area in which the mobile host moves. The process during which a mobile host enters a new cell is called *hand-off*. To accommodate smooth hand-off, cells usually overlap.

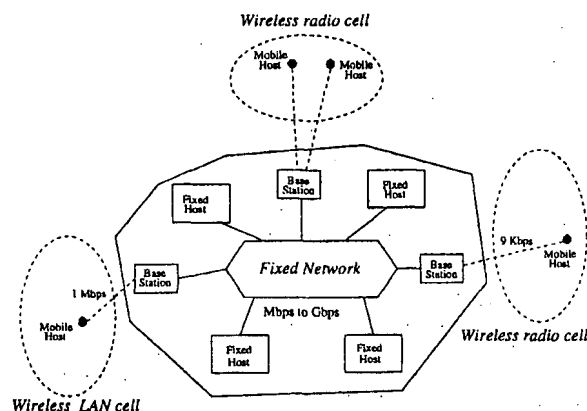


Figure 1: Mobile System Architecture

2.1 The Wireless Medium

The networking infrastructure (also called Personal Communication Network (PCN)) is expected to include [9, 15, 3]:

- *cellular or packet radio modems* (e.g., Ericson GE's Mobidem), which are characterized by high costs, large range coverage, and relatively small bandwidth;
- *satellite services* (e.g., Motorola's Iridium), which provide wide coverage, but are very expensive, usually receive-only and of very low bandwidth; and
- *wireless LANs* (traditional LANs extended with a wireless interface, e.g., NCR WaveLAN, Motorola's ALTAIR, Proxims Range LAN and Telesystem's ARLAN), which provide connectivity with low cost within a very small geographical area (at a range of few kilometers).

While the growth in physical network bandwidth has been tremendous (in current technology Ethernet provides 10Mbps, FDDI 100 Mbps and ATM 155 Mbps), products for wireless communication achieve only 2Mbps for radio communication, and 9-14 kbps for cellular telephony [9]. The typical bandwidth of wireless LANs ranges from 250 bps to 2Mbps and it is expected to increase to 10Mbps. Since the bandwidth is divided between the users sharing a shell, the deliverable bandwidth per user will be even lower. Thus, it is safe to assume that bandwidth will continue to be a scarce resource. Furthermore, an additional reason that makes bandwidth consumption a major concern of mobile computing designs, is that data transmission over the air is *monetarily expensive* [12].

In comparison with non-mobile environments, disconnections are much more frequent. Furthermore, the wireless medium is characterized by much greater variation in network bandwidth than traditional designs, leading to various *degrees of disconnections* depending on the available bandwidth and noise of the communication channel [9, 14]. Certain disconnections are considered *foreseeable*, since they can

be detected by changes in the signal strength, by predicting the battery's lifetime, or by utilizing knowledge of the bandwidth distribution [3, 14].

Product	RAM	MHz	CPU	Batteries hours, type	Weight lbs	Display sq. inches
Amstard Pen Pad PDA600	128 KB	20	Z80	40, AAAs	0.9	10.4
Apple Newton Message Pad	640KB	20	ARM	6-8, 4 AAAs	0.9	11.2
At&T EO 440	4-12 MB	20	Hobbit	1-6, NiCad	2.2	25.7

Table 1: Typical Values of Mobile Hosts

2.2 Mobile Hosts

Mobile hosts, regardless of future technology advances, will have limited computing power, memory and screen size as a result of their small size and weight. Some typical values are shown in Table 1 [9]. Mobile hosts range from small palmtops (e.g., Apple Newton) or specialized data entry devices (like the ones used by UPS) to tabletop computers with wireless interfaces (e.g., AT&T EO). Mobile hosts have limited battery capacity, two or three hours under normal use, which is expected to increase only 20% over the next 10 years. Due to this fact, energy preservation is an important consideration. Moreover, mobile hosts are more susceptible to loss, destruction and theft than static hosts. Table 2 summarizes the characteristics of the wireless medium and of the mobile hosts.

characteristics of the wireless medium	characteristics of mobile hosts
low bandwidth frequent disconnections high bandwidth variability predictable disconnections monetarily expensive broadcast is physically supported in a cell	small size small screen limited battery life susceptible to theft, and accidents

Table 2: Summary of the Characteristics

3 System Overview

In this section we provide an overview of an information system for a mobile environment. First, we define the modes of operation, then we describe the general architecture, and finally, we conclude with two important considerations in the design of the system.

3.1 Operation Modes

While in a nonmobile distributed system a host operates in one of two modes regarding its connection to the rest of the network (either connected to it or totally disconnected from it) in a mobile environment there are more modes of operation. We model the different modes of operation of a mobile host using the state diagram shown in Figure 2.

The degree of connection is related to the availability of bandwidth. Since total and partial disconnections are very frequent, they should not be treated as failures. On the contrary, a mobile host should be capable of operating even under low or no connection with the fixed network. A

mobile host operates in a *partly disconnected* mode when the communication through the wireless network is weak.

In addition to the modes related to the type of connection with the fixed network, a mobile host may switch to the *doze mode* for preserving energy. While in this mode, the clock speed is reduced and no user computation is performed. The mobile host returns to normal operation upon receipt of any message.

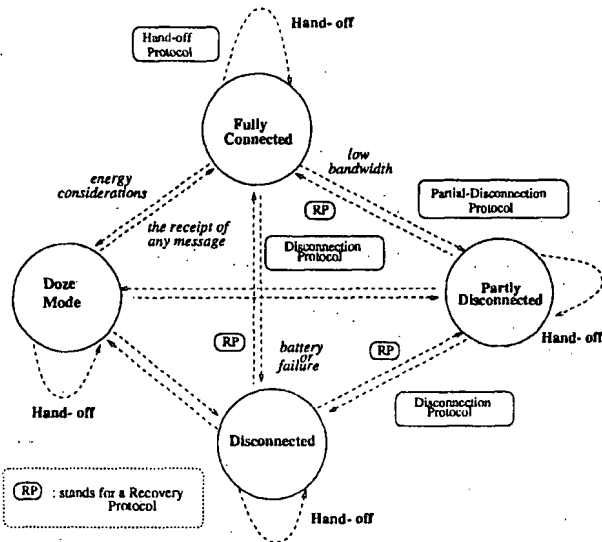


Figure 2: Operation Modes of a Mobile Host

Since most of the transitions between modes are predictable, protocols can be designed to prepare the system for a transition.

- A *disconnection protocol* is executed before the mobile host is physically detached from the fixed network. The protocol should ensure that enough information is locally available to the mobile host for its autonomous operation during disconnection. It should also notify any interested parties for the forecoming disconnection.
- A *partial-disconnection protocol* prepares the mobile host for operation in a mode where all communication with the fixed network should be as restricted as possible. Selective caching can be used for caching data, whose presence in the host will minimize future network use.
- *Recovery protocols* re-establish the connection with the fixed network and resume normal operation.
- *Hand-off protocols* refer to crossing the boundaries of a cell. State information pertaining to the mobile host should be transferred to the base station of the new cell.

Part of these protocols is handled by low-level system operations. However, the modes are not necessarily completely transparent to the applications. Support by the application

(in our case by the information management system) can lead to performance gains. For example, information about the type of application can be used to design caching techniques or limit network access.

In this paper, we focus on how system support for transactions and consistency maintenance can take into account the modes of operation to increase performance and availability. Specifically, in Section 4, we present a replication controller, which adjusts with the type of connection. In Section 5, we introduce the concept of transaction migration to handle hand-offs.

3.2 The Architecture of the Information System

Users of mobile hosts will have access to a variety of information resources, which will be located in both mobile and static hosts. An architecture for such systems must take into account the following facts:

- Although, some of the information resources will be provided by information systems especially tailored for such use, many of them will be provided by *pre-existing* applications that were built without taking into account the possibility of their future access through wireless connections. Rather than rebuilding the applications, superimposing upon them appropriate interfaces is a more realistic approach.
- An intrinsic characteristic of these information resources is their *heterogeneity*. Heterogeneity is the inevitable result of an expected increase in the scale of distributed systems with the introduction of mobile hosts. Furthermore, the use of wireless connections results in users entering new cells and possibly heterogeneous environment during a single session.
- The architecture must support extensibility and portability. Compliance with evolving standards such as CORBA [11] and ODP [24] is a step towards this direction.

Because of the above considerations, an *object-based architecture* seems to be appropriate to serve as the architecture of a mobile information system. A Distributed Object Management System (DOMS) consists of a number of distributed hosts and clients [19]. Each host supports one or more information systems. Together, the hosts constitute the system's information resources. Special *Object Servers* or *Object Managers* are responsible for building appropriate interfaces so that the system's resources appear as objects. Clients request operations by sending messages to objects. These messages are handled by object servers which direct them to the appropriate hosts.

Object-based architectures are suitable for the following reasons:

- Special *Mobile-Object Servers* can be built that will offer appropriate methods for accessing data from mobile hosts. These methods will account for the wireless of the medium and the fact that the location of a client is a frequently changing data, see Figure 3.
- Object-based architectures hide the heterogeneity of the environment, since the response to a message depends only on the interface and not on the internal implementation of the object or the method.
- Most proposals for standards are based on the distributed object paradigm.

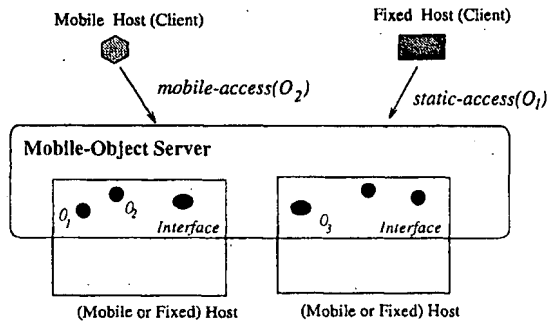


Figure 3: Object-based Architecture, objects O_i correspond to resources stored in static and mobile hosts

The distributed object-based architecture provides the high-level architecture of the distributed heterogeneous information system. Internally, each information system that participates in the object-based architecture may support its own data model. What would be an appropriate internal data model for a local mobile database is not clear yet, but it should support graphical interfaces and take into account the inherent heterogeneity of the mobile environment [2].

Location Databases. In addition to the servers that will provide wireless access to general information resources, the system should maintain servers that offer access to information systems that contain location-related information. We assume at least two such databases, one per user that would include the user's home address and other user-related information and one per base station that would include information about all hosts under its cell. Location databases are:

- fast changing,
- geographical,
- distributed and replicated over many sites to support efficient access,
- imprecise, since the overhead for keeping them up-to-date may be overwhelming.

Data stored in location databases may participate in queries. This results in queries that are:

- of different complexity in terms of location constraints,
- geographical and moreover dependent on the location of the user (e.g. find the nearest restaurant),
- real-time,
- imprecise,
- dependent on the user's direction of move

Query issues involving location data are discussed in [16]. In Section 4, we discuss issues regarding the consistency of such data.

3.3 Two Important Considerations

Two issues of particular interest in designing information systems for mobile environments are to determine the role of a mobile host in a distributed computation and to *personalize* the computation. We discuss them further.

The Role of a Mobile Host. There is no agreement yet on the role of a mobile host in a distributed environment. The possibilities range from that of a dumb terminal with no autonomy to that of a relatively independent component with enough memory and computing power to perform part of the distributed computation locally. Each approach has both advantages and disadvantages. Performing part of the computation on a mobile host:

- costs in terms of power consumption,
- complicates data replication and integrity preservation,
- adds to the search cost of locating the mobile hosts and the data that they produce and consume.

On the other hand, it

- allows the autonomous operation of a mobile host during partial and total disconnections,
- limits bandwidth use,
- saves the energy cost for the transmission of data to and from the fixed network.

In our design, we adopt the approach that part of the computation will be executed in a mobile host, since allowing a mobile host to operate autonomously is crucial considering the frequency of disconnections. But still, since mobile hosts are susceptible to failures and accidents, part of the computation must be reported to the fixed network. In Section 5, we introduce the notion of transaction proxies that provides transaction support for backing-up the computation in the fixed network.

User's Profile. Utilizing information about users gains increasing importance as information systems scale in size. We assume that this information is stored in a *user's profile*. Information about users is very important to data navigation since it can be used to select the information that is of interest to a particular user. For instance, users may be informed for the release of the latest album of their favored artist. Specifically in mobile environments, the user's profile may also include information about the user's *mobility pattern*, for instance the fact that each day he commutes to his office. The user's profile can be part of the location database of the user.

In mobile systems research the user's profile has been widely used, for example to determine which data to cache before disconnections [18], or to optimize queries about location [16]. In our schema, we propose utilizing information stored in a user's profile to define consistency clusters (Section 4) and to simulate mobility (Section 6).

4 Consistency of Replicated Data

Communication through the wireless network is very expensive both monetarily and in terms of bandwidth consumption. As a consequence, performing operations locally in

a mobile host can lead to performance gains and increase availability during total and partial disconnections. On the other hand, maintaining full consistency among data saved in fixed and mobile hosts imposes unbearable overheads in mobile environments [3, 14, 20]. We propose a more flexible model. The formal definition of the model, its scope and the associated correctness criteria are presented in [21]. The presentation of the model in this section aims at demonstrating how the operation modes and the other general considerations are taken into account in designing the replication controller of our information system.

4.1 Clustering

We partition the data items of a mobile database into *clusters*. All replicas in a cluster are synchronized, while replicas at different clusters may vary by some appropriately defined degree. In that sense, a cluster is the unit of consistency. The degree of inconsistency may vary based on the availability of network bandwidth by allowing small deviation among the copies in cases of higher bandwidth availability and higher deviation in cases of low bandwidth availability. The cluster configuration is *dynamic* rather than static. When clusters are merged the values of all copies of a data item are reconciled.

Defining Degrees. There are many alternative ways of defining degrees [22]. The *degree* may express the divergence from the value of the primary copy [1]. In this case, the allowable degree may be bounded by limiting the number of versions, by setting a maximum value on the allowable deviation, or by limiting the number of transactions that can operate on inconsistent values. Alternatively, we can define the degree as the number of data items or the number of data copies per data item that can diverge.

Defining Clusters. One possible way of defining a cluster is by grouping together data residing in the same or neighboring hosts. For instance, data stored in hosts that are partially or totally disconnected from the fixed network may be considered as forming a cluster (Figure 4). In this case, by taking advantage of the predictable nature of disconnections, clusters of data may be created or merged upon a forecoming disconnection or connection of the associated mobile host. Furthermore, clusters may be defined based on the type of data. A characteristic example of such data is the data representing the *location* of mobile hosts. Since this type of data are fast-changing, the maintenance of their full consistency could cause unbearable overheads. In addition, users may explicitly define clusters based on the semantics of their data or applications. Finally, information stored in a *user's profile* may also be utilized to determine clusters. For example, data that are most frequently accessed by a user or data that are to a great extent private to a user can be considered as belonging to the same cluster independently of their location.

4.2 Handling Loose Consistency

To maximize local processing and limit network accesses, we allow users to interact with locally (within a cluster) available data by introducing two new kinds of operations, loose reads and loose writes. These operations allow users to operate on loosely consistent data when the lack of strict consistency does not affect the semantics of their transactions. Allowing users to operate on local data is especially

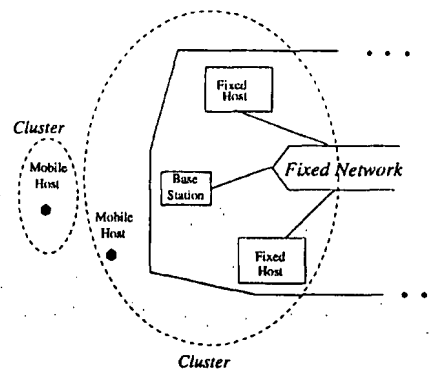


Figure 4: A possible cluster configuration, where clustering is based on location

important during total or partial disconnection since those data are then the only data that are accessible or affordable to access. We call the standard read and write operations *strict read* and *strict write* operations to differentiate them from the loose operations.

Specifically, a loose read ($LR[a]$) reads the value written by the last loose or strict write operation on a *locally* available copy, that is on a copy in its cluster. A *loose write* operation ($LW[a]$) writes some local copies and is not permanent unless it is finally committed after cluster merging. A *strict read* operation ($SR[a]$) reads the value written by the last strict write operation on a copy located in *any* of the clusters. Finally, the value written by a *strict write* operation ($SW[a]$) becomes permanent after commitment. Our method can be implemented as a 2-version method, where local transaction managers maintain two copies of a data item, one that is updated by strict writes and one that is updated by both strict and loose writes. The first is read by strict read operations and the second by loose read operations.

Two Types of Basic Transactions. We distinguish two types of transactions:

- (a) transactions that consist only of loose read and loose write operations and are called *loose transactions*; and
- (b) transactions that consist only of strict read and strict write operations and are called *strict transactions*.

Loose transactions are locally committed in their associated clusters. Updates performed by locally committed transactions are revealed only to other loose transactions in the same cluster. These changes are revealed to strict transactions only after merging, when local transactions become globally committed. Before being globally committed, a loose transaction may be undone even after it has been locally committed.

A loose transaction is a transaction that may read loosely consistent data and whose writes may be undone any time before merging. Strict transactions have the usual semantics. Loose transactions are suitable for applications that do not require exact values of data such as gathering information for statistical purposes. Allowing updates in loose

	$LR_j(a_k)$	$SR_j(a_k)$	$LW_j(a_k)$	$SW_j(a_k)$
$LR_i(a_k)$			X	X
$SR_i(a_k)$				X
$LW_i(a_k)$	X		X	X
$SW_i(a_k)$	X	X	X	X

Table 3: Conflict relation, a "x" entry indicates that the operations for the given row and column conflict. Row entries correspond to operations of transaction T_i and column entries to operations of a transaction T_j , where $i \neq j$

transactions adds functionality. These updates are finally committed only if they do not conflict with the operations of a strict transaction. Thus, loose updates are especially useful in two cases: (a) for handling private or seldomly accessed data for which conflicts are rare, and (b) for transactions for which compensating actions are possible.

Users or application developers are able to specify the loose or strict requirements of their transactions through a high-level interface. Then, the operations of each transaction are automatically translated into loose or strict operations according to the given specifications.

Correctness. Two operations of the same transaction conflict if they both access the same data copy and at least one of them is a write. Operations of two different transactions that are executed before cluster merging conflict as shown in Table 3. Upon merging of clusters we adopt a strictly syntactic approach to establishing full consistency. We undo all loose transactions whose loose writes conflict with a strict transaction. We have proven that undoing a loose transaction can result in undoing only loose transactions in the same cluster [21]. Serializability-based criteria for the correctness of schedules before and after merging are formally defined in [21]. In [21], we have also presented graph-based tests for the serializability of the corresponding schedules and compare our work with other weak consistency proposals in the database and operating system communities.

5 Transactions in a Mobile Environment

Loose and strict transactions are generic transactions that can be considered *part* of a general mobile transaction that models the interaction of a user with a mobile distributed system. Generally speaking, a *mobile transaction* is a distributed transaction T , where some parts of the computation are executed on mobile and some parts on nonmobile hosts. The model for such a transaction that involves data stored in both the fixed and the wireless network has not emerged yet.

A large number of transactions in a mobile environment is expected to be read-only transactions, where users will query large amount of data. Still, some applications such as inventory control, banking applications and travel reservations will require updates. For instance, a traveling salesman

will update an inventory database to reflect the fact that an item has been sold. Consumers will use their mobile host to book flights, buy tickets or do banking transactions.

An important issue is what part and how large a part of a transaction will be executed on a mobile host. This is related to the role of a mobile host in a mobile distributed environment. Operations on a mobile host may minimize network access, and optimize response time. On the other hand, they cost in terms of local resource consumption (especially battery). But the decisive factor for answering this question is frequent disconnections. To allow the operation of a mobile host during disconnections part of the computation must be executed locally.

The Characteristics of Mobile Transactions. We identify the following as the characteristics of a mobile transaction:

- Mobile transactions are transactions that involve the wireless network and may be executed in both mobile and nonmobile hosts.
- Using the *wireless medium* has the following consequences. Transactions tend to be:
 1. monetarily expensive;
 2. long lived, because of long network delays;
 3. error-prone, because of frequent disconnections but also because mobile hosts are more prone to accidents than fixed hosts; and
 4. session-based. For some technologies, such as cellular modems, there is a high start-up charge for each communication. Cost-effective transaction management may adopt the approach of supporting few long-lived session-based transactions instead of many short-lived transactions.
- *Mobility* results in transactions with the following characteristics:
 1. Transactions access heterogeneous information systems.
 2. Transactions access (possibly imprecise) location data.
 3. Transactions may involve data that are dynamically relocated.

Modeling Mobile Transactions. Mobile transactions are long-running, error-prone and heterogeneous. As a consequence, modeling mobile transactions as ACID transactions is very restrictive. ACID transactions have limited expressive power and offer no way of modeling computations with a complex control structure. Furthermore, ACID transactions do not support partial commitment or abortion of a transaction, or partial recovery. Finally, there is no way of "suspending" a transaction to survive a disconnection.

It seems that an *open-nested model* [10] is more appropriate for modeling mobile transactions. In that model, each transaction consists of a number of subtransactions with a specified set of dependencies. The set of dependencies varies based on the application and it can be customized. In [7], an axiomatic definition of a transaction model for mobile transactions is presented. Our approach is different in that, instead of defining a powerful, general transaction model,

we identify the *generic characteristics* that this model must support to be appropriate for a mobile environment.

Specifically, to deal with the particularities of the wireless medium, we have introduced *loose transactions*. Loose transactions support disconnected operation and minimize bandwidth use. Moreover, they are capable of modeling operations on imprecise data, such as location data. In this section we investigate further on the structure of mobile transactions. We present two generic techniques:

- To deal with the mobility of the environment we introduce the concept of *transaction migration*.
- To deal with the vulnerability of the mobile hosts we introduce the concept of a *transaction proxy*.

5.1 Transaction Migration

A mobile host may enter a new cell while in operation. In that case, it may be necessary to *migrate* part of the computation that was executed in one fixed host to another fixed host. One motivation for migration is improvement in performance. By moving the computation close to the mobile host, the communication cost is minimized. Transaction migration (relocation) can be thought of as the dual of data relocation. In addition, transaction migration may lead to a better load balance among base stations. Furthermore, a base station may not be willing to support computation initiated by users that are not any more in its cell, for instance for security reasons. In that case, transactions submitted to the old base station and partially executed there must be transferred to the new base station.

Let T_i be a transaction that was initially submitted at site i and then was migrated to site j . We use the notation T_{i-} for the part executed at site i and T_{j-} for the part executed at site j . T_{i-} cannot be committed at site i but it may conditionally release some of the local resources it holds. T_{j-} inherits state information from T_{i-} . That information depends on the consistency control method used. It may include timestamps, requested and granted locks, or log files.

5.2 Transaction Proxies

To deal with the fact that mobile hosts are more susceptible to theft accidents and frequent disconnections, we must report part of the computation that is performed in a mobile host to the fixed network. We model that using the concept of *transaction proxies*. For each transaction T_i executed at a mobile host i , we define a dual transaction PT_j , called proxy, that will be executed on host j , where j is the base station of i .

A proxy transaction may be considered as a subtransaction of the original transaction. Thus, any time a subtransaction is submitted to a mobile host its proxy transaction is submitted to its base station. The proxy transaction includes only the updates of the original transaction. Alternatively, proxy transactions may be executed off-line. In that sense, proxy transactions correspond to taking periodic back-ups of the computation which is performed on a mobile host. We are investigating necessary criteria for scheduling proxies at fixed hosts in a sound and efficient way.

6 Status Report

We are currently developing an information system on top of ORAID [5]. ORAID is an object-oriented system built

on top of RAID [6], a distributed database system that has been proven successful in supporting experiments in communication, adaptability, and transaction processing. We are modifying the communication library routines [26] to simulate the wireless communication. Mobility is captured by connecting our simulated mobile station with different base stations. We assign to each host that simulates a mobile host, a fixed host which serves as its base station. The mobile host can then directly communicate only with its assigned base station. The assignment of base stations to mobile hosts is dynamic and is driven by the mobility pattern as specified in each user's profile.

In addition to the traditional performance measurements mobile computing introduces new performance concerns, including:

- energy preservation (battery is a limited resource);
- prudent use of bandwidth (bandwidth in mobile environment is a very scarce and expensive resource); and
- the degree of autonomy during weak or total disconnections (since disconnections are frequent, mobile computers should be able to operate even while disconnected).

We intend to provide system support for loose transactions, migration and proxies and study the performance of these mechanisms.

7 Summary

Wireless communications offer the exciting possibility of accessing information independent of location and movement. This possibility raises new challenges to the design of information systems. In this paper we have reported on the design of such a system. The contribution of this paper is twofold. First we have:

- defined the operation modes of a mobile host;
- proposed a general object-based architecture for information systems appropriate for mobile environments; and
- identified the main concerns in designing mobile information systems.

Second, we have shown how these general principles can be used to provide system support for transactions in a mobile environment. Specifically, we have introduced:

- loose transactions to deal with the frequent, predictable and of various degrees disconnections,
- transaction migration to model mobility, and
- transaction proxies to handle recovery.

Finally, we have briefly reported on the status of our system and discussed performance criteria for testing the proposed techniques.

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↑ ABSTRACT

It is expected that in the near future, tens of millions of users will have access to distributed information systems through wireless connections. The technical characteristics of the wireless medium and the resulting mobility of both data resources and data consumers raise new challenging questions regarding the development of information systems appropriate for mobile environments. In this paper, we report on the development of such a system. First, we describe the general architecture of the information system and the main considerations of our design. Then, based on these considerations, we present our system support for maintaining the consistency of replicated data and for providing transaction schemas that account for the frequent but predictable disconnections, the mobility, and the vulnerability of the wireless environment.







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Lou Montulli, Electronic Mail to multiple recipients of the www-talk list (www-talk@www10.w3.org) on "Session Tracking" (omi.mail.www-talk, Apr. 18, 1995).

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PR: Online Security Solutions, "VeriSign, Inc. Adds the Missing Component to Online Security Solutions" Internet, Sep. 18, 1995, pp. 1-2.

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Peterson, Larry L., "A Yellow-Pages Service for a Local-Area Network", ACM Proceedings of the ACM SIGCOMM 87 Workshop, ACM Press, 1988, pp. 235-242.

ART-UNIT: 272

PRIMARY-EXAMINER: Lee; Thomas C.

ASSISTANT-EXAMINER: Kim; Ki S.

ATTY-AGENT-FIRM: Hamilton, Brook, Smith & Reynolds, P.C.

ABSTRACT:

This invention relates to methods for providing access to network servers. In particular, the process described in the invention includes client-server sessions over the Internet involving hypertext files. In the hypertext environment, a client views a document transmitted by a content server with a standard program known as the browser. Each hypertext document or page contains links to other hypertext pages which the user may select to traverse. The user may also access a hypertext page by providing a conventional telephone number or other descriptor. The server maps such a telephone number or descriptor to a target page identifier using a translation database and automatically directs the client to retrieve the desired page.

2 Claims, 7 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	IMC	Draw D
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☐ 2. Document ID: JP 2006309753 A, WO 9642041 A2, AU 9659367 A, WO 9642041 A3, US 5708780 A, EP 830774 A2, AU 694367 B, US 5812776 A, JP 11507752 W, JP 2002157180 A, EP 830774 B1, DE 69633564 E, DE 69633564 T2, JP 3762882 B2, US 5708780 C1, JP 2006134319 A

L1: Entry 2 of 2

File: DWPI

Nov 9, 2006

DERWENT-ACC-NO: 1997-065577

DERWENT-WEEK: 200675

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TITLE: Client/server service request processing method for WWW - involves forwarding service request from client to server system which is returned with session identifier allowing access history monitoring

INVENTOR: GIFFORD, D K; LEVERGOOD, T M; MORRIS, S J; PAYNE, A C; STEWART, L C; TREESE, G W; GIFFORD, K; LEVERGOOD, M; MORRIS, J; PAYNE, C; STEWART, C; TREESE, W

PATENT-ASSIGNEE: OPEN MARKET INC (OPENN), DIVINE TECHNOLOGY VENTURES (DIVIN), D & I SYSTEMS KK (DISYN)

PRIORITY-DATA: 1995US-0486797 (June 7, 1995), 1995US-0474096 (June 7, 1995)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
<u>JP 2006309753 A</u>	November 9, 2006		051	G06F013/00
<u>WO 9642041 A2</u>	December 27, 1996	E	069	G06F000/00
<u>AU 9659367 A</u>	January 9, 1997		000	G06F019/00
<u>WO 9642041 A3</u>	March 13, 1997		000	G06F000/00
<u>US 5708780 A</u>	January 13, 1998		067	G06F015/56
<u>EP 830774 A2</u>	March 25, 1998	E	000	H04L029/06
<u>AU 694367 B</u>	July 16, 1998		000	G06F017/30
<u>US 5812776 A</u>	September 22, 1998		000	G06F015/16
<u>JP 11507752 W</u>	July 6, 1999		070	G06F015/00
<u>JP 2002157180 A</u>	May 31, 2002		044	G06F013/00
<u>EP 830774 B1</u>	October 6, 2004	E	000	H04L029/06
<u>DE 69633564 E</u>	November 11, 2004		000	H04L029/06
<u>DE 69633564 T2</u>	November 24, 2005		000	H04L029/06
<u>JP 3762882 B2</u>	April 5, 2006		047	G06F013/00
<u>US 5708780 C1</u>	April 4, 2006		000	G06F015/16
<u>JP 2006134319 A</u>	May 25, 2006		050	G06F021/00

DESIGNATED-STATES: AU CA DE GB IL JP AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

CITED-DOCUMENTS:2.Jnl.Ref; EP 456920 ; EP 645688 ; WO 9403959

APPLICATION-DATA:

PUB-NO	APPL-DATE	APPL-NO	DESCRIPTOR
JP2006309753A	June 3, 1996	1997JP-0503084	Div ex
JP2006309753A	April 11, 2006	2006JP-0108796	
WO 9642041A2	June 3, 1996	1996WO-US07838	
AU 9659367A	June 3, 1996	1996AU-0059367	
AU 9659367A		WO 9642041	Based on
WO 9642041A3	June 3, 1996	1996WO-US07838	
US 5708780A	June 7, 1995	1995US-0474096	
EP 830774A2	June 3, 1996	1996EP-0916695	
EP 830774A2	June 3, 1996	1996WO-US07838	

EP 830774A2		WO 9642041	Based on
AU 694367B	June 3, 1996	1996AU-0059367	
AU 694367B		AU 9659367	Previous Publ.
AU 694367B		WO 9642041	Based on
US 5812776A	June 7, 1995	1995US-0486797	
JP 11507752W	June 3, 1996	1996WO-US07838	
JP 11507752W	June 3, 1996	1997JP-0503084	
JP 11507752W		WO 9642041	Based on
JP2002157180A	June 3, 1996	1997JP-0503084	Div ex
JP2002157180A	June 3, 1996	2001JP-0208296	
EP 830774B1	June 3, 1996	1996EP-0916695	
EP 830774B1	June 3, 1996	1996WO-US07838	
EP 830774B1		WO 9642041	Based on
DE 69633564E	June 3, 1996	1996DE-0633564	
DE 69633564E	June 3, 1996	1996EP-0916695	
DE 69633564E	June 3, 1996	1996WO-US07838	
DE 69633564E		EP 830774	Based on
DE 69633564E		WO 9642041	Based on
DE 69633564T2	June 3, 1996	1996DE-0633564	
DE 69633564T2	June 3, 1996	1996EP-0916695	
DE 69633564T2	June 3, 1996	1996WO-US07838	
DE 69633564T2		EP 830774	Based on
DE 69633564T2		WO 9642041	Based on
JP 3762882B2	June 3, 1996	1997JP-0503084	Div ex
JP 3762882B2	July 9, 2001	2001JP-0208296	
JP 3762882B2		JP2002157180	Previous Publ.
US 5708780C1	June 7, 1995	1995US-0474096	
JP2006134319A	June 3, 1996	1997JP-0503084	Div ex
JP2006134319A	October 20, 2005	2005JP-0305380	

2006134319 A INT-CL (IPC): G06F 0/00; G06F 13/00; G06F 15/00; G06F 15/16; G06F 15/56; G06F 15/82; G06F 17/30; G06F 19/00; G06F 21/00; G06F 21/20; G09C 1/00; H04L 9/32; H04L 12/54; H04L 12/58; H04L 29/06; H04L 29/08; H04M 11/00

ABSTRACTED-PUB-NO: US 5708780A

BASIC-ABSTRACT:

The service request processing method involves forwarding a service request from a client to the server system. A session identifier is returned from the server system to the client. The session identifier is appended to the request and subsequent service requests from the client to the server system within a session of requests.

The server system tracks an access history of sequences of service requests within a session of requests to determine requests leading to a purchase made within the request session. The server system counts requests to particular services exclusive of repeated requests from a common client. A database of customer information is maintained containing access patterns and demographics.

ADVANTAGE - Allows client tracing. Provides security for private LANs.

ABSTRACTED-PUB-NO: US 5812776A
EQUIVALENT-ABSTRACTS:

The service request processing method involves forwarding a service request from a client to the server system. A session identifier is returned from the server system to the client. The session identifier is appended to the request and subsequent service requests from the client to the server system within a session of requests.

The server system tracks an access history of sequences of service requests within a session of requests to determine requests leading to a purchase made within the request session. The server system counts requests to particular services exclusive of repeated requests from a common client. A database of customer information is maintained containing access patterns and demographics.

ADVANTAGE - Allows client tracing. Provides security for private LANs.

The service request processing method involves forwarding a service request from a client to the server system. A session identifier is returned from the server system to the client. The session identifier is appended to the request and subsequent service requests from the client to the server system within a session of requests.

The server system tracks an access history of sequences of service requests within a session of requests to determine requests leading to a purchase made within the request session. The server system counts requests to particular services exclusive of repeated requests from a common client. A database of customer information is maintained containing access patterns and demographics.

ADVANTAGE - Allows client tracing. Provides security for private LANs.

WO 9642041A

CHOSEN-DRAWING: Dwg.2a/6 Dwg.3/6

DERWENT-CLASS: P85 T01
EPI-CODES: T01-H07C5A; T01-H07C5E; T01-S01B;

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	Index	Drawings				
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Terms	Documents															
5812776.pn.	2															

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Search Results - Record(s) 1 through 2 of 2 returned.

☐ 1. Document ID: US 5805820 A

L2: Entry 1 of 2

File: USPT

Sep 8, 1998

US-PAT-NO: 5805820

DOCUMENT-IDENTIFIER: US 5805820 A

TITLE: Method and apparatus for restricting access to private information in domain name systems by redirecting query requests

DATE-ISSUED: September 8, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bellovin; Steven Michael	Westfield	NJ		
Cheswick; William Roberts	Bernardsville	NJ		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
AT&T Corp.	Middletown	NJ			02

APPL-NO: 08/679466 [PALM]

DATE FILED: July 15, 1996

INT-CL-ISSUED: [06] G06F 15/163

INT-CL-CURRENT:

TYPE	IPC	DATE
CIPS	<u>H04 L</u>	<u>29/06</u> 20060101
CIPS	<u>H04 L</u>	<u>29/12</u> 20060101

US-CL-ISSUED: 395/200.55; 707/9, 707/10, 395/187.01, 395/188.01, 395/200.59

US-CL-CURRENT: 709/225; 707/10, 707/9, 709/229, 726/12

FIELD-OF-CLASSIFICATION-SEARCH: 707/9, 707/10, 395/187.01, 395/188.01, 395/200.33, 395/200.48, 395/200.55, 395/200.59

See application file for complete search history.

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>5204961</u>	April 1993	Barlow	395/725
<u>5416842</u>	May 1995	Aziz	380/30
<u>5519858</u>	May 1996	Walton et al.	395/600
<u>5548649</u>	August 1996	Jacobson	380/49
<u>5550984</u>	August 1996	Gelb	395/200.17
<u>5586260</u>	December 1996	Hu	395/200.2
<u>5606668</u>	February 1997	Schwed	395/200.11
<u>5614927</u>	March 1997	Gifford et al.	707/101
<u>5623601</u>	April 1997	Vu	395/187.01
<u>5655077</u>	August 1997	Jones et al.	395/187.01
<u>5664185</u>	September 1997	Landfield et al.	707/104

OTHER PUBLICATIONS

Greenwald et al., "designing an academic firewall: policy, practice, and experience with SURF", Network and Distributed system security symposium, IEEE, pp. 79-92, 1996.

ART-UNIT: 271

PRIMARY-EXAMINER: Black; Thomas G.

ASSISTANT-EXAMINER: Homere; Jean R.

ABSTRACT:

A device and method redirect query requests to restrict access to private information of a domain in a domain name system. The device includes a switching device that redirects query requests for the private information from within the domain to a device within the domain. The private information includes IP addresses and domain names. All the devices in the domain may be modified to direct all query requests to the switching device or the switching device may be incorporated into a firewall of the domain.

20 Claims, 13 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	RMK	Draw. De
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2. Document ID: JP 2006262532 A, EP 820176 A2, JP 10111848 A, US 5805820 A, CA 2209611 A, CA 2209648 A, US 5958052 A, MX 9705262 A1, CA 2209648 C, CA 2209611 C, MX 204786 B, MX 207768 B, EP 820176 B1, DE 69734179 E, DE 69734179 T2

L2: Entry 2 of 2

File: DWPI

Sep 28, 2006

DERWENT-ACC-NO: 1998-079181

DERWENT-WEEK: 200664

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TITLE: Information filtering subsystem for domain name system - filters information from first device of first domain and generates filtered information by removing

private information and forwarding this filtered information to second device of second domain

INVENTOR: BELLOVIN, S M; CHESWICK, W R

PATENT-ASSIGNEE: AT & T CORP (AMTT), AMERICAN TELEPHONE & TELEGRAPH CO (AMTT)

PRIORITY-DATA: 1996US-0683019 (July 16, 1996), 1996US-0679466 (July 15, 1996)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
<u>JP 2006262532 A</u>	September 28, 2006		017	H04L012/66
<u>EP 820176 A2</u>	January 21, 1998	E	019	H04L029/06
<u>JP 10111848 A</u>	April 28, 1998		017	G06F013/00
<u>US 5805820 A</u>	September 8, 1998		000	G06F015/163
<u>CA 2209611 A</u>	January 15, 1998		000	G06F012/14
<u>CA 2209648 A</u>	January 16, 1998		000	G06F012/14
<u>US 5958052 A</u>	September 28, 1999		000	G06F011/00
<u>MX 9705262 A1</u>	September 1, 1998		000	G06F009/00
<u>CA 2209648 C</u>	January 4, 2000	E	000	G06F012/14
<u>CA 2209611 C</u>	April 11, 2000	E	000	G06F012/14
<u>MX 204786 B</u>	October 18, 2001		000	G06F009/00
<u>MX 207768 B</u>	May 10, 2002		000	G06F009/00
<u>EP 820176 B1</u>	September 14, 2005	E	000	H04L029/06
<u>DE 69734179 E</u>	October 20, 2005		000	H04L029/06
<u>DE 69734179 T2</u>	June 29, 2006		000	H04L029/06

DESIGNATED-STATES: AL AT BE CH DE DK ES FI FR GB GR IE IT LI LT LU LV MC NL PT RO SE SI DE FR GB

APPLICATION-DATA:

PUB-NO	APPL-DATE	APPL-NO	DESCRIPTOR
JP2006262532A	July 15, 1997	1997JP-0189349	Div ex
JP2006262532A	June 5, 2006	2006JP-0155655	
EP 820176A2	July 8, 1997	1997EP-0304969	
JP 10111848A	July 15, 1997	1997JP-0189349	
US 5805820A	July 15, 1996	1996US-0679466	
CA 2209611A	July 3, 1997	1997CA-2209611	
CA 2209648A	July 3, 1997	1997CA-2209648	
US 5958052A	July 15, 1996	1996US-0679466	Cont of
US 5958052A	July 16, 1996	1996US-0683019	
US 5958052A		US 5805820	Cont of
MX 9705262A1	July 11, 1997	1997MX-0005262	
CA 2209648C	July 3, 1997	1997CA-2209648	
CA 2209611C	July 3, 1997	1997CA-2209611	
MX 204786B	July 11, 1997	1997MX-0005260	
MX 207768B	July 11, 1997	1997MX-0005262	
EP 820176B1	July 8, 1997	1997EP-0304969	
DE 69734179E	July 8, 1997	1997DE-0634179	

DE 69734179E	July 8, 1997	1997EP-0304969	
DE 69734179E		EP 820176	Based on
DE 69734179T2	July 8, 1997	1997DE-0634179	
DE 69734179T2	July 8, 1997	1997EP-0304969	
DE 69734179T2		EP 820176	Based on

INT-CL (IPC): G06F 9/00; G06F 11/00; G06F 12/14; G06F 13/00; G06F 13/14; G06F 15/163; G06K 9/00; H04L 12/28; H04L 12/56; H04L 12/66; H04L 29/06; H04L 29/12

RELATED-ACC-NO: 1998-180890

ABSTRACTED-PUB-NO: EP 820176A
BASIC-ABSTRACT:

The subsystem includes a filtering device that receives information (520) from a first device of a first domain destined to a second device of a second domain. The filtering device generates filtered information (522) by removing private information of the second domain from the information and forwarding the filtered information to the second device of the second domain.

Preferably the private information of the second domain includes at least one of a domain name and an IP address of a device of the second domain. Preferably the information is sent by the first device in response to a query request by the second device. The information includes additional information that was not requested by the second device and which is filtered out before delivery to the second device.

USE - E.g. for restricting access to private information in domain name systems.

ADVANTAGE - Removes any possibility for device within domain to receive private information from device external to domain.

ABSTRACTED-PUB-NO: US 5805820A
EQUIVALENT-ABSTRACTS:

The subsystem includes a filtering device that receives information (520) from a first device of a first domain destined to a second device of a second domain. The filtering device generates filtered information (522) by removing private information of the second domain from the information and forwarding the filtered information to the second device of the second domain.

Preferably the private information of the second domain includes at least one of a domain name and an IP address of a device of the second domain. Preferably the information is sent by the first device in response to a query request by the second device. The information includes additional information that was not requested by the second device and which is filtered out before delivery to the second device.

USE - E.g. for restricting access to private information in domain name systems.

ADVANTAGE - Removes any possibility for device within domain to receive private information from device external to domain.

US 5958052A

The subsystem includes a filtering device that receives information (520) from a first device of a first domain destined to a second device of a second domain. The filtering device generates filtered information (522) by removing private information of the second domain from the information and forwarding the filtered information to the second device of the second domain.

Preferably the private information of the second domain includes at least one of a domain name and an IP address of a device of the second domain. Preferably the information is sent by the first device in response to a query request by the second device. The information includes additional information that was not requested by the second device and which is filtered out before delivery to the second device.

USE - E.g. for restricting access to private information in domain name systems.

ADVANTAGE - Removes any possibility for device within domain to receive private information from device external to domain.

DERWENT-CLASS: W01

EPI-CODES: W01-A07G;

Full	Title	Citation	Front	Review	Classification	Date	Reference				Claims	KOMC	Draw D
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Search Results - Record(s) 1 through 2 of 2 returned.

☐ 1. Document ID: US 5748954 A

L3: Entry 1 of 2

File: USPT

May 5, 1998

US-PAT-NO: 5748954

DOCUMENT-IDENTIFIER: US 5748954 A

TITLE: Method for searching a queued and ranked constructed catalog of files stored on a network

DATE-ISSUED: May 5, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Mauldin; Michael L.	Penn Hills	PA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Carnegie Mellon University	Pittsburgh	PA			02

APPL-NO: 08/462520 [PALM]

DATE FILED: June 5, 1995

INT-CL-ISSUED: [06] G06F 17/30

INT-CL-CURRENT:

TYPE	IPC	DATE
CIPP	G06 F 17/30	20060101

US-CL-ISSUED: 395/610; 395/611

US-CL-CURRENT: 707/10; 707/100FIELD-OF-CLASSIFICATION-SEARCH: 395/600, 395/601, 395/616, 395/610, 395/611
See application file for complete search history.

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>4713754</u>	December 1987	Agrawal et al.	364/200

<u>5408655</u>	April 1995	Oren et al.	395/600
<u>5446740</u>	August 1995	Yien et al.	370/110.1
<u>5446891</u>	August 1995	Kaplan et al.	395/600
<u>5488725</u>	January 1996	Turtle et al.	395/600
<u>5495607</u>	February 1996	Pisello et al.	395/600
<u>5530852</u>	June 1996	Meske, Jr. et al.	395/600

OTHER PUBLICATIONS

Loke et al, Compound Document Processing System, IEEE, pp. 640-644 Jan. 1991.
 Li et al, Internet Resource Discovery Services, IEEE, pp. 8-22 Jan. 1993.
 Mauldin et al, Web Agent Related Research at the Center for Machine Translation, To be presented at the SIGNIDR meeting, pp. 1-6 Aug. 1994.
 Pinkerton, Finding What People Want: Experinces with the Web Crawler, The Design of the WebCrawler, pp. 1-10 Jan. 1994.
 Bowman et al, Harvest: A Scalable, Customizable Discovery and Access System, Technical Report CU-CS 7329-94, pp. 1-27, Aug. 1994.
 New Spiders Roam the Web, Computer-Mediated Communication Mazagine, vol. 1, No. 5, Sep. 1, 1994, p. 3, John December.
 Web Agent Related Research at the center for Machine Translation, To be presented at the SIGNIDR meeting Aug. 4, 1994 in McLean, Michael L. Mauldin, John R. R. Leavitt.

ART-UNIT: 237

PRIMARY-EXAMINER: Black; Thomas G.

ASSISTANT-EXAMINER: Coby; Frantz

ATTY-AGENT-FIRM: Kirkpatrick & Lockhart LLP

ABSTRACT:

A method of constructing a catalog of files stored on a network comprised of a plurality of interconnected computers each having a plurality of files stored thereon. The method is accomplished by establishing a queue containing at least one address representative of a file stored on one of the interconnected computers, ranking each address in the queue according to the popularity of the file presented by the address, downloading the file corresponding to the address in the queue having the highest ranking, processing the downloaded file to generate certain information about the downloaded file for the catalog, adding to the queue any addresses found in the downloaded file, and determining the popularity of file represented by the addresses in the queue according to how often a file is referenced by a computer other than the computer on which the file is stored.

38 Claims; 13 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	MMIC	Draw D
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☐ 2. Document ID: US 5748954 A

L3: Entry 2 of 2

File: DWPI

May 5, 1998

DERWENT-ACC-NO: 1998-286281
DERWENT-WEEK: 200353
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TITLE: Distributed file storage catalog construction for internet - involves ranking stored file queue according to heuristic and popping file at top of queue for download and file information generation for catalog

INVENTOR: MAULDIN, M L

PATENT-ASSIGNEE: UNIV CARNEGIE MELLON (UYCAN)

PRIORITY-DATA: 1995US-0462520 (June 5, 1995)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
<u>US 5748954 A</u>	May 5, 1998		016	G06F017/30

APPLICATION-DATA:

PUB-NO	APPL-DATE	APPL-NO	DESCRIPTOR
US 5748954A	June 5, 1995	1995US-0462520	

INT-CL (IPC): G06F 17/30

RELATED-ACC-NO: 2003-566758

ABSTRACTED-PUB-NO: US 5748954A
BASIC-ABSTRACT:

The catalog construction method involves establishing a queue containing at least one address representative of a file stored on one of the interconnected computers. Each address in the queue is ranked according to a heuristic. The file corresponding to the address in the queue having the highest ranking is downloaded. The downloaded file is processed to generate certain information about the downloaded file for the catalog. Any addresses found in the downloaded file are added to the queue.

This process is repeated. Address ranking includes ranking each address according to the popularity of the file represented by that address. The downloaded file processing includes storing link text, and merging the link text to generate information about files referenced in the downloaded files for the catalog.

ADVANTAGE - Provides accurate file search results. Processes information in meaningful manner.

ABSTRACTED-PUB-NO: US 5748954A
EQUIVALENT-ABSTRACTS:

CHOSEN-DRAWING: Dwg.6/10

DERWENT-CLASS: T01 W01
EPI-CODES: T01-J05B2B; T01-J05B3; W01-A06B7;

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	RMIC	Draw D
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Search Results - Record(s) 1 through 2 of 2 returned.☐ 1. Document ID: US 5721832 A

L7: Entry 1 of 2

File: USPT

Feb 24, 1998

US-PAT-NO: 5721832

DOCUMENT-IDENTIFIER: US 5721832 A

TITLE: Method and apparatus for an interactive computerized catalog system

DATE-ISSUED: February 24, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Westrope; Robert John	Toronto			CA
Martin; Bruce Edward	Mississauga			CA
Lyons; John Bernard	Richmond Hill			CA

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Regal Greetings & Gifts Inc.	Toronto			CA	03

APPL-NO: 08/439595 [PALM]

DATE FILED: May 12, 1995

INT-CL-ISSUED: [06] H01J 13/00

INT-CL-CURRENT:

TYPE IPC	DATE
CIPS <u>G06 Q 30/00</u>	20060101
CIPS <u>H04 M 3/487</u>	20060101
CIPS <u>H04 M 3/493</u>	20060101

US-CL-ISSUED: 395/227; 395/210, 348/13, 379/92, 235/383

US-CL-CURRENT: 705/27; 235/383, 379/93.12, 705/10, 725/60, 725/9

FIELD-OF-CLASSIFICATION-SEARCH: 346/401, 346/403, 346/406, 380/25, 235/383, 235/385, 235/375, 235/380, 395/227, 395/210, 348/13, 348/55, 379/92

See application file for complete search history.

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>Re30773</u>	October 1981	Glaser et al.	235/379
<u>Re31951</u>	July 1985	Johnson	369/900
<u>4584604</u>	April 1986	Nakagawa	348/55
<u>4603232</u>	July 1986	Kurland	379/92
<u>4792849</u>	December 1988	McCalley et al.	358/86
<u>4816904</u>	March 1989	McKenna	395/13
<u>4972504</u>	November 1990	Daniel	395/210
<u>5053956</u>	October 1991	Donald	364/403
<u>5088586</u>	February 1992	Isobe	364/403
<u>5195130</u>	March 1993	Weiss et al.	379/98
<u>5253341</u>	October 1993	Rozmanith et al.	395/200
<u>5315504</u>	May 1994	Lemble	364/400
<u>5315508</u>	May 1994	Bain et al.	364/401
<u>5451998</u>	September 1995	Hamkick	364/403
<u>5475585</u>	December 1995	Bush	364/403
<u>5528490</u>	June 1996	Hill	364/403

OTHER PUBLICATIONS

"Electronic Shopping, Computer Catalogs"; Popular Science Jul. 1994, p. 41.

ART-UNIT: 267

PRIMARY-EXAMINER: Mullen; Thomas

ASSISTANT-EXAMINER: Wong; Albert K.

ATTY-AGENT-FIRM: Rader Fishman & Grauer PLLC

ABSTRACT:

The present invention relates to an improved method and apparatus for an interactive, computerized catalog system in which a customer can selectively access video and audio catalog data from a computerized catalog memory that permits a customer to peruse an entire catalog of products or services or select specific portions from specific catalogs or services and if desired place an order which is processed electronically and from which customer profile marketing data is selectively generated.

10 Claims, 8 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KMC	Draw
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2. Document ID: CA 2176297 A, US 5968110 A, US 5721832 A

L7: Entry 2 of 2

File: DWPI

Nov 13, 1996

DERWENT-ACC-NO: 1997-333185

DERWENT-WEEK: 199950

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TITLE: Interactive computerised catalogue system - initiating order processing sequence and payment to permit user to enter product order from telephone and enabling user to be included in customer profile marketing file created from catalogue product order transactions

INVENTOR: LYONS, J B; MARTIN, B E ; WESTROPE, R J

PATENT-ASSIGNEE: REGAL GREETING & GIFTS INC (REGAN), REGAL GREETINGS & GIFTS INC (REGAN), HARDWARE STREET INC (HARDN)

PRIORITY-DATA: 1995US-0439595 (May 12, 1995), 1997US-0936245 (September 24, 1997)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
<u>CA 2176297 A</u>	November 13, 1996		038	H04M011/08
<u>US 5968110 A</u>	October 19, 1999		000	E01B015/00
<u>US 5721832 A</u>	February 24, 1998		012	H01J013/00

APPLICATION-DATA:

PUB-NO	APPL-DATE	APPL-NO	DESCRIPTOR
CA 2176297A	May 10, 1996	1996CA-2176297	
US 5968110A	May 12, 1995	1995US-0439595	Cont of
US 5968110A	September 24, 1997	1997US-0936245	
US 5968110A		US 5721832	Cont of
US 5721832A	May 12, 1995	1995US-0439595	

INT-CL (IPC): E01B 15/00; G06F 17/60; H01J 13/00; H04M 11/08

ABSTRACTED-PUB-NO: CA 2176297A

BASIC-ABSTRACT:

The interactive computerised catalogue process comprises storing digitised graphic catalogue data in an addressable computer system memory. A menu index of catalogue products and services comprising the catalog data available is generated for selective viewing at any user's telephone terminal screen.

A communication link is established between a user's telephone terminal and the computer system memory. The menu of catalogue products and services data to a user's telephone terminal is transmitted in response to a user's initial request. The catalogue data which corresponds to the user's product request signal is transmitted from the computer system memory.

An order processing sequence, including a financial payment authorisation process, is initiated to permit a user to enter, from a user telephone terminal, a product order to be processed and delivered in response to the user's order.

A user is enabled when placing an order to elect to be included in or to be excluded from a customer profile marketing data file created from completed catalogue product order transactions.

ADVANTAGE - Efficient product and service selectivity to prospective customers and

which selectively generate market profile data of users and customers.

ABSTRACTED-PUB-NO: US 5721832A

EQUIVALENT-ABSTRACTS:

The interactive computerised catalogue process comprises storing digitised graphic catalogue data in an addressable computer system memory. A menu index of catalogue products and services comprising the catalog data available is generated for selective viewing at any user's telephone terminal screen.

A communication link is established between a user's telephone terminal and the computer system memory. The menu of catalogue products and services data to a user's telephone terminal is transmitted in response to a user's initial request. The catalogue data which corresponds to the user's product request signal is transmitted from the computer system memory.

An order processing sequence, including a financial payment authorisation process, is initiated to permit a user to enter, from a user telephone terminal, a product order to be processed and delivered in response to the user's order.

A user is enabled when placing an order to elect to be included in or to be excluded from a customer profile marketing data file created from completed catalogue product order transactions.

ADVANTAGE - Efficient product and service selectivity to prospective customers and which selectively generate market profile data of users and customers.

US 5968110A

The interactive computerised catalogue process comprises storing digitised graphic catalogue data in an addressable computer system memory. A menu index of catalogue products and services comprising the catalog data available is generated for selective viewing at any user's telephone terminal screen.

A communication link is established between a user's telephone terminal and the computer system memory. The menu of catalogue products and services data to a user's telephone terminal is transmitted in response to a user's initial request. The catalogue data which corresponds to the user's product request signal is transmitted from the computer system memory.

An order processing sequence, including a financial payment authorisation process, is initiated to permit a user to enter, from a user telephone terminal, a product order to be processed and delivered in response to the user's order.

A user is enabled when placing an order to elect to be included in or to be excluded from a customer profile marketing data file created from completed catalogue product order transactions.

ADVANTAGE - Efficient product and service selectivity to prospective customers and which selectively generate market profile data of users and customers.

CHOSEN-DRAWING: Dwg.1/8 Dwg.6/8

DERWENT-CLASS: Q41 T01 W01

EPI-CODES: T01-J05A; W01-C05B3C; W01-C05B5C;

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KIMC	Draw D
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